

AMENDMENTS TO THE CLAIMS

- 1 1. (Previously Presented) A method of establishing a secure communication session
2 among a plurality of member nodes that participate in a multicast group across a wide
3 area network, comprising the steps of:
4 receiving information defining a plurality of multicast proxy service nodes, wherein:
5 the plurality of multicast service nodes are distributed across the wide area
6 network;
7 the plurality of multicast service nodes control when any of the plurality of
8 member nodes join or leave the multicast group; and
9 the plurality of multicast proxy service nodes are logically represented by a
10 first binary tree, wherein:
11 each node of the first binary tree is associated with a domain of a
12 plurality of domains of a directory service that is distributed
13 across the wide area network; and
14 each node of the first binary tree is associated with one or more
15 multicast proxy service nodes of the plurality of multicast
16 proxy service nodes;
17 creating and storing a second binary tree that represents the plurality of member
18 nodes, wherein:
19 each of the member nodes of the plurality of member nodes is represented by
20 a leaf node of the second binary tree;
21 the second binary tree is stored in a particular domain of the plurality of
22 domains of the directory service that is distributed across the wide area
23 network;
24 a root node of the second binary tree represents one or more of the multicast
25 proxy service nodes of the plurality of multicast proxy service nodes;
26 and
27 each of the member nodes of the plurality of member nodes is capable of
28 establishing multicast communication and serving as a key distribution
29 center;

30 creating and storing a group session key associated with the multicast group and a
31 private key associated with each member node of the multicast group using
32 secure key exchange;
33 when an additional member node joins the multicast group, determining a new group
34 session key by replicating a branch of the second binary tree.

1 2. (Previously Presented) A method as recited in Claim 1, wherein each of the member
2 nodes is associated with at least one of the multicast proxy service nodes, wherein
3 each of the multicast proxy service nodes acts as one of a plurality of group
4 controllers, further comprising the steps of:
5 joining an additional group controller to the plurality of group controllers, wherein
6 each group controller of the plurality of group controllers is a replica of
7 another group controller of the plurality of group controllers;
8 establishing, by one of the group controllers, a secure communication channel
9 between one of the group controllers and another of the group controllers
10 using a key exchange protocol;
11 receiving a request to add or delete a specified member node of the multicast group
12 from a load balancer that is coupled to the plurality of group controllers;
13 creating and storing the new group session key for each member node in each branch
14 of the second binary tree that is affected by adding or deleting the specified
15 member node from the multicast group;
16 distributing the new group session key from one of the group controllers to the
17 member nodes that are affected by adding or deleting the specified member
18 node.

1 3. (Canceled)

1 4. (Previously Presented) A method as recited in Claim 2, wherein distributing the new
2 group session key further comprises the steps of:
3 determining that the specified member node is leaving the multicast group;
4 determining which of the intermediate nodes of the second binary tree are affected by
5 the specified member node that is leaving;

6 updating only keys associated with the intermediate nodes that are affected by the
7 specified member node that is leaving; and
8 sending the new group session key to the leaf nodes of the second binary tree that
9 correspond to the member nodes that are affected by deleting the specified
10 member node.

1 5. (Canceled)

1 6. (Previously Presented) A method as recited in Claim 2, wherein distributing the new
2 group session key further comprises the steps of:
3 receiving a request message from the specified member node to join the multicast
4 group;
5 determining which of the intermediate nodes of the second binary tree are affected by
6 the specified member node that is joining the multicast group;
7 updating only keys associated with the intermediate nodes that are affected by the
8 specified member node that is joining;
9 generating a private key for the specified member node that is joining; and
10 sending a message comprising the new group session key, the private key, and the
11 updated keys of intermediate nodes that are affected to the member node that
12 is joining.

1 7-9. (Canceled)

1 10. (Previously Presented) A method as recited in Claim 1, wherein determining the new
2 group session key further comprises the step of computing a group shared secret key
3 at a first member node of the plurality of member nodes for use in a public key
4 process and using less than $n * (n-1)$ messages, where "n" is a number of member
5 nodes in the multicast group, by the steps of:
6 generating an intermediate shared secret key by issuing communications to a second
7 member node of the plurality of member nodes;
8 sending a first private value associated with the first member node to the second
9 member node;

10 receiving from the second member node a second private value associated with the
11 second member node using the intermediate shared secret key;
12 generating and communicating a collective public key that is based upon the first
13 private value and the second private value to a third member node of the
14 plurality of member nodes;
15 receiving an individual public key from the third member node; and
16 computing and storing the group shared secret key based upon the individual public
17 key.

1 11. (Canceled)

1 12. (Previously Presented) A method as recited in Claim 10, wherein the step of
2 communicating the collective public key further comprises the step of determining
3 whether the first member node or the second member node transfers the collective
4 public key based upon an order of entry of the first and second member nodes into the
5 multicast group.

1 13-14. (Canceled)

1 15. (Previously Presented) A method as recited in Claim 10, wherein computing and
2 storing the group shared secret key further comprises the steps of computing and
3 storing a group shared secret key value "k" at the first member node according to the
4 relation:

5
$$k = C^{ab} \bmod (q) = p^{abc} \bmod (q);$$

6 wherein:

7 C, a, b, c, q, and p are values stored in a memory,

8 C is the individual public key,

9 a is the first private value of the first member node,

10 b is the second private value of the second member node,

11 c is a third private value of the third member node,

12 p is a base value, and

13 q is a prime number value.

1 16. (Previously Presented) A method as recited in Claim 1, wherein determining the new
2 group session key further comprises the step of computing a group shared secret key,
3 each of the member nodes of the plurality of member nodes having a private key
4 associated therewith, by the steps of:
5 communicating a first public key of a first member node of the plurality of member
6 nodes to a second member node of the plurality of member nodes;
7 creating and storing an initial shared secret key for the first member node and the
8 second member node based on a first private key and a second public key that
9 is received from the second member node;
10 creating and storing information at the first member node that associates the first
11 member node with a first entity by generating a collective public key that is
12 shared by the first member node and the second member node, wherein the
13 collective public key is based on the first private key and a second private key
14 that is derived by the first member node from the second public key;
15 receiving a third public key from a third member node of the plurality of member
16 nodes that seeks to join the first entity;
17 creating and storing a final shared secret key based on the collective public key and a
18 third public key;
19 joining the first member node to a second entity that includes the first entity and the
20 third member node and that uses secure communication with messages that
21 are encrypted using the final shared secret key.

1 17-19. (Canceled)

1 20. (Previously Presented) A method as recited in Claim 16, further comprising the steps
2 of creating and storing a subsequent shared secret key for use by the first entity and
3 the third member node to enable the third member node to independently compute the
4 group shared secret key, wherein creating and storing the subsequent shared secret
5 key further comprises the steps of creating and storing a subsequent shared secret key
6 value, k , according to the relation:

7 $k = p^{(a*x)(b*y)(c*z)} \bmod (q)$

8 where:

9 p = a random number,

10 q = a prime number,

11 a = the first private key,

12 b = the second private key,

13 c = a third private key of the third member node,

14 x = a number of times the first member node has participated in entity
15 formation,

16 y = a number of times the second member node has participated in entity
17 formation, and

18 z = a number of times the third member node has participated in entity
19 formation.

1 21-22. (Canceled)

1 23. (Previously Presented) A method as recited in Claim 16, wherein creating and storing
2 the initial shared secret key for the first member node and second member node
3 further comprises the steps of creating and storing an initial shared public key value
4 "AB" according to the relation:

5 $AB = k_{ab}^{ab} \bmod (q) = p^{(ab)(ab)} \bmod (q)$

6 wherein:

7 k = the initial shared secret key,

8 a = the first private key,

9 b = the second private key,

10 p is a base value, and

11 q is a randomly generated prime number.

1 24. (Previously Presented) A method as recited in Claim 1, further comprising the steps
2 of:

3 authenticating a first multicast proxy service node with a subset of the multicast

4 proxy service nodes of the plurality of multicast proxy service nodes that are

5 affected by an addition of the first multicast proxy service node to the
6 multicast group, based on key information stored in a directory;
7 wherein authenticating the first multicast proxy service node based on key
8 information stored in the directory includes authenticating the first multicast
9 proxy service node based on the directory that comprises a directory system
10 agent (DSA) for communicating with one or more of the multicast proxy
11 service nodes and a replication service agent (RSA) for replicating attribute
12 information of one or more multicast proxy service nodes, wherein the
13 attribute information comprises the group session key and the private keys of
14 the one or more multicast proxy service nodes;
15 receiving a plurality of private keys from the subset of multicast proxy service nodes;
16 generating a new private key for the first multicast proxy service node;
17 communicating the plurality of private keys and the new private key to the first
18 multicast proxy service node;
19 communicating a message to the subset of multicast proxy service nodes that causes
20 the subset of multicast proxy service nodes to update their private keys;
21 distributing the new group session key to all multicast proxy service nodes of the
22 plurality of multicast proxy service nodes by the steps of:
23 creating and storing the new group session key using a particular multicast
24 proxy service node of a particular domain of the plurality of domains
25 of the directory service, wherein the particular domain is associated
26 with the directory;
27 replicating the directory; and
28 obtaining the new group session key from a local multicast proxy service node
29 that is a replica of the first multicast proxy service node.

1 25-30. (Canceled)

1 31. (Previously Presented) A method as recited in Claim 24, further comprising the step
2 of selectively updating the group session key and the private keys, wherein the step of
3 selectively updating further comprises the steps of:

4 detecting whether a member node of the plurality of member nodes that is associated
5 with one of the leaf nodes is leaving the multicast group;
6 determining one or more tree nodes along a tree path in the second binary tree that
7 corresponds to the leaving leaf node, wherein the one or more tree nodes are
8 affected in response to the detecting step;
9 updating the private keys of the one or more tree nodes;
10 one of the affected intermediate nodes that is a parent node of the leaving leaf node
11 generating the new group session key and selectively sending the new group
12 session key to all ancestral nodes along the tree path;
13 modifying the key information based upon the updated private keys and the new
14 group session key; and
15 generating instructions that distribute the modified key information using directory
16 replication.

1 32-33. (Canceled)

1 34. (Previously Presented) A method as recited in Claim 24, further comprising the step
2 of selectively updating the group session key and the private keys, wherein the step of
3 selectively updating further comprises the steps of:
4 receiving a request message from a new member node to join the multicast group;
5 determining one or more tree nodes along a tree path in the second binary tree that
6 corresponds to a new leaf node in the second binary tree for the new member
7 node, wherein the one or more nodes are affected in response to the receiving
8 step;
9 updating the private keys of the one or more tree nodes;
10 one of the affected intermediate nodes that is a parent node of the new leaf node
11 requesting permission from a root node of the second binary tree to generate
12 the new session key and generating the new group session key and a private
13 key of the new leaf node;
14 modifying the key information based upon the updated private keys, the new group
15 session key, and the private key of the new leaf node; and
16 generating instructions that distribute the modified key information using directory
17 replication.

1 35-37. (Canceled)

1 38. (Previously Presented) A method as recited in Claim 1, further comprising the steps
2 of:
3 storing the group session key associated with the multicast group in a directory of the
4 directory service;
5 authenticating a first multicast proxy service node with a subset of multicast proxy
6 service nodes of the plurality of multicast proxy service nodes that are
7 affected by an addition of the first multicast proxy service node to the
8 multicast group, based on the group session key stored in the directory;
9 receiving a plurality of private keys from the subset of multicast proxy service nodes;
10 receiving the new group session key for the multicast group, for use after addition of
11 the first multicast proxy service node, from a directory system agent (DSA) of
12 a local multicast proxy service node that has received the new group session
13 key through periodic replication of the directory by a replication service agent
14 (RSA) of the local multicast proxy service node, wherein the RSA is signaled
15 to carry out replication by storing an updated group session key in a local
16 node of the directory;
17 communicating the new group session key to the first multicast proxy service node;
18 communicating a message to the subset of multicast proxy service nodes that causes
19 the subset of multicast proxy service nodes to update their private keys.

1 39-41. (Canceled)

1 42. (Previously Presented) A method as recited in Claim 38, further comprising the steps
2 of:
3 distributing the group session key to all member nodes of the plurality of member
4 nodes by creating and storing the group session key using a particular
5 multicast proxy service node of the plurality of multicast proxy service nodes,
6 wherein the particular multicast proxy service node is associated with a
7 particular domain of the plurality of domains, and wherein the particular
8 domain is associated with the directory;

9 replicating the directory; and
10 obtaining the group session key from a local multicast proxy service node that is a
11 replica of the particular multicast proxy service node.

1 43-46. (Canceled)

1 47. (Previously Presented) A method as recited in Claim 38, further comprising the steps
2 of:
3 associating a plurality of intermediate nodes of the second binary tree with a plurality
4 of multicast service agents;
5 establishing a secure back channel group among the plurality of multicast service
6 agents;
7 updating the group session key to all the multicast service agents in the plurality of
8 multicast service agents by securely communicating the group session key
9 using a secure back channel that is associated with the secure back channel
10 group;
11 at each intermediate node of the plurality of intermediate nodes, updating the group
12 session key of only those leaf nodes that are child nodes of said each
13 intermediate node.

1 48. (Previously Presented) A method as recited in Claim 38, further comprising the steps
2 of:
3 receiving a request for the group session key from a publisher node that is located in a
4 different domain of the plurality of domains from the particular domain in
5 which is stored the second binary tree;
6 determining an identifier of the publisher node using a first directory service agent
7 that is associated with a particular multicast proxy service node of the
8 plurality of multicast proxy service nodes, wherein the particular multicast
9 proxy service node is in the particular domain;
10 establishing a secure communication channel among the particular multicast proxy
11 service node and a directory service agent that is associated with a different

12 multicast proxy service node of the plurality of multicast proxy service nodes,
13 wherein the different multicast proxy service node is in the different domain.

1 49-50. (Canceled)

1 51. (Previously Presented) A method as recited in Claim 1, further comprising the step of
2 managing removal of a first member node from the multicast group, wherein
3 managing removal of the first member node further comprises the steps of:
4 creating and storing the group session key associated with the multicast group and a
5 private key associated with each member node of the plurality of member
6 nodes in a directory;
7 receiving information indicating that the first member node is leaving the multicast group;
8 updating all affected keys of a subset of member nodes of the plurality of member
9 nodes in a branch of the second binary tree that contains the first member
10 node that is leaving;
11 receiving the new group session key for the multicast group, for use after removal of
12 the first member node, and a new private key for a parent node of the first
13 member node, from a local multicast proxy service node of the plurality of
14 multicast proxy service nodes;
15 communicating a message to the subset of member nodes that causes the subset of
16 member nodes to update their private keys.

1 52-53. (Canceled)

1 54. (Previously Presented) A method as recited in Claim 51, further comprising the steps
2 of:
3 associating a plurality of intermediate nodes of the second binary tree with a plurality
4 of multicast service agents;
5 establishing a secure back channel group among the plurality of multicast service
6 agents;
7 updating the group session key to all the multicast service agents in the plurality of
8 multicast service agents by securely communicating the group session key

9 using a secure back channel that is associated with the secure back channel
10 group;
11 at each intermediate node of the plurality of intermediate nodes, updating the group
12 session key of only those leaf nodes that are child nodes of said each
13 intermediate node.

1 55. (Previously Presented) A method as recited in Claim 51, further comprising the steps
2 of:
3 receiving a request for the group session key from a publisher node that is located in a
4 different domain of the plurality of domains from the particular domain in
5 which is stored the second binary tree;
6 determining an identifier of the publisher node using a first directory service agent
7 that is associated with a particular multicast proxy service node of the
8 plurality of multicast proxy service nodes, wherein the particular multicast
9 proxy service node is in the particular domain;
10 establishing a secure communication channel among the particular multicast proxy
11 service node and a directory service agent that is associated with a different
12 multicast proxy service node of the plurality of multicast proxy service nodes,
13 wherein the different multicast proxy service node is in the different domain.

1 56. (Previously Presented) A method as recited in Claim 51, further comprising the steps
2 of:
3 distributing the group session key to all member nodes of the plurality of member
4 nodes by creating and storing the group session key using a particular
5 multicast proxy service node of the plurality of multicast proxy service nodes,
6 wherein the particular multicast proxy service node is associated with a
7 particular domain of the plurality of domains, and wherein the particular
8 domain is associated with the directory;
9 replicating the directory; and
10 obtaining the group session key from a local multicast proxy service node that is a
11 replica of the particular multicast proxy service node.

1 57-58. (Canceled)

1 59. (Previously Presented) A computer-readable medium carrying one or more
2 sequences of instructions for establishing a secure communication session among a
3 plurality of member nodes that participate in a multicast group across a wide area
4 network, wherein execution of the one or more sequences of instructions by one or
5 more processors causes the one or more processors to perform the steps of:
6 receiving information defining a plurality of multicast proxy service nodes, wherein:
7 the plurality of multicast service nodes are distributed across the wide area
8 network;
9 the plurality of multicast service nodes control when any of the plurality of
10 member nodes join or leave the multicast group; and
11 the plurality of multicast proxy service nodes are logically represented by a
12 first binary tree, wherein:
13 each node of the first binary tree is associated with a domain of a
14 plurality of domains of a directory service that is distributed
15 across the wide area network; and
16 each node of the first binary tree is associated with one or more
17 multicast proxy service nodes of the plurality of multicast
18 proxy service nodes;
19 creating and storing a second binary tree that represents the plurality of member
20 nodes, wherein:
21 each of the member nodes of the plurality of member nodes is represented by
22 a leaf node of the second binary tree;
23 the second binary tree is stored in a particular domain of the plurality of
24 domains of the directory service that is distributed across the wide area
25 network;
26 a root node of the second binary tree represents one or more of the multicast
27 proxy service nodes of the plurality of multicast proxy service nodes;
28 and

29 each of the member nodes of the plurality of member nodes is capable of
30 establishing multicast communication and serving as a key distribution
31 center;
32 creating and storing a group session key associated with the multicast group and a
33 private key associated with each member node of the multicast group using
34 secure key exchange;
35 when an additional member node joins the multicast group, determining a new group
36 session key by replicating a branch of the second binary tree.

1 60-80. (Canceled)

1 81. (Currently Amended) An apparatus for establishing a secure communication session
2 among a plurality of member nodes that participate in a multicast group across a wide
3 area network, the apparatus comprising:
4 means for receiving information defining a plurality of multicast proxy service
5 nodes~~[[,]] wherein: the plurality of multicast service nodes~~ that are distributed
6 across the wide area network;~~the plurality of multicast service nodes and that~~
7 are operable to control when any of the plurality of member nodes join or
8 leave the multicast group; ~~and~~
9 means for creating and storing a first binary tree that represents the plurality of
10 multicast proxy service nodes ~~are logically represented by a first binary tree,~~
11 wherein:
12 each node of the first binary tree is associated with a domain of a plurality of
13 domains of a directory service that is distributed across the wide area
14 network; and
15 each node of the first binary tree is associated with one or more multicast
16 proxy service nodes of the plurality of multicast proxy service nodes;
17 means for creating and storing, in a particular domain of the plurality of domains of
18 the directory service that is distributed across the wide area network, a second
19 binary tree that represents the plurality of member nodes, wherein:
20 each of the member nodes of the plurality of member nodes is represented by
21 a leaf node of the second binary tree;

~~the second binary tree is stored in a particular domain of the plurality of
domains of the directory service that is distributed across the wide area
network;~~

a root node of the second binary tree represents one or more of the multicast
proxy service nodes of the plurality of multicast proxy service nodes;
and

each of the member nodes of the plurality of member nodes is ~~capable of~~
operable to establish[[ing]] multicast communication and to
serv[[ing]]e as a key distribution center;

means for creating and storing a group session key associated with the multicast
group and a private key associated with each member node of the multicast
group using secure key exchange;

means for determining a new group session key by replicating a branch of the second
binary tree when an additional member node joins the multicast group.

82. (Previously Presented) An apparatus as recited in Claim 81, wherein each of the
member nodes is associated with at least one of the multicast proxy service nodes,
wherein each of the multicast proxy service nodes acts as one of a plurality of group
controllers, and the apparatus further comprises:
means for joining an additional group controller to the plurality of group controllers,
wherein each group controller of the plurality of group controllers is a replica
of another group controller of the plurality of group controllers;
means for establishing, by one of the group controllers, a secure communication
channel between one of the group controllers and another of the group
controllers using a key exchange protocol;
means for receiving a request to add or delete a specified member node of the
multicast group from a load balancer that is coupled to the plurality of group
controllers;
means for creating and storing the new group session key for each member node in
each branch of the second binary tree that is affected by adding or deleting the
specified member node from the multicast group;

17 means for distributing the new group session key from one of the group controllers to
18 the member nodes that are affected by adding or deleting the specified
19 member node.

1 83. (Previously Presented) An apparatus as recited in Claim 82, wherein the means for
2 distributing the new group session key further comprises:
3 means for determining that the specified member node is leaving the multicast group;
4 means for determining which of the intermediate nodes of the second binary tree are
5 affected by the specified member node that is leaving;
6 means for updating only keys associated with the intermediate nodes that are affected
7 by the specified member node that is leaving; and
8 means for sending the new group session key to the leaf nodes of the second binary
9 tree that correspond to the member nodes that are affected by deleting the
10 specified member node.

1 84. (Previously Presented) An apparatus as recited in Claim 82, wherein the means for
2 distributing the new group session key further comprises:
3 means for receiving a request message from the specified member node to join the
4 multicast group;
5 means for determining which of the intermediate nodes of the second binary tree are
6 affected by the specified member node that is joining the multicast group;
7 means for updating only keys associated with the intermediate nodes that are affected
8 by the specified member node that is joining;
9 means for generating a private key for the specified member node that is joining; and
10 means for sending a message comprising the new group session key, the private key,
11 and the updated keys of intermediate nodes that are affected to the member
12 node that is joining.

1 85. (Currently Amended) An apparatus as recited in Claim 81, wherein the means for
2 determining the new group session key further comprises means for computing a
3 group shared secret key at a first member node of the plurality of member nodes for
4 use in a public key process and using less than $n * (n - \lceil \log_2 n \rceil)$ messages, wherein "n" is

5 a number of member nodes in the multicast group, wherein the means for
 6 comput[er]ing the group shared secret key further comprises:
 7 means for generating an intermediate shared secret key by issuing communications to
 8 a second member node of the plurality of member nodes;
 9 means for sending a first private value associated with the first member node to the
 10 second member node;
 11 means for receiving from the second member node a second private value associated
 12 with the second member node using the intermediate shared secret key;
 13 means for generating and communicating a collective public key that is based upon
 14 the first private value and the second private value to a third member node of
 15 the plurality of member nodes;
 16 means for receiving an individual public key from the third member node; and
 17 means for computing and storing the group shared secret key based upon the
 18 individual public key.

1 86. (Previously Presented) An apparatus as recited in Claim 85, wherein the means for
 2 communicating the collective public key further comprises means for determining
 3 whether the first member node or the second member node transfers the collective
 4 public key based upon an order of entry of the first and second member nodes into the
 5 multicast group.

1 87. (Previously Presented) An apparatus as recited in Claim 85, wherein the means for
 2 computing and storing the group shared secret key further comprises means for
 3 computing and storing a group shared secret key value "k" at the first member node
 4 according to the relation:

$$5 \quad k = C^{ab} \bmod (q) = p^{abc} \bmod (q);$$

6 wherein:

7 C, a, b, c, q, and p are values stored in a memory,
 8 C is the individual public key,
 9 a is the first private value of the first member node,
 10 b is the second private value of the second member node,
 11 c is a third private value of the third member node,

p is a base value, and
q is a prime number value.

88. (Currently Amended) An apparatus as recited in Claim 81, wherein the means for determining the new group session key further comprises means for computing a group shared secret key, each of the member nodes of the plurality of member nodes having a private key associated therewith, wherein the means for computing the group shared secret key further comprises:

- means for communicating a first public key of a first member node of the plurality of member nodes to a second member node of the plurality of member nodes;
- means for creating and storing an initial shared secret key for the first member node and the second member node based on a first private key and a second public key that is received from the second member node;
- means for creating and storing information at the first member node that associates the first member node with a first entity by generating a collective public key that is shared by the first member node and the second member node, wherein the collective public key is based on the first private key and a second private key that is derived by the first member node from the second public key;
- means for receiving a third public key from a third member node of the plurality of member nodes that seeks to join the first entity;
- means for creating and storing a final shared secret key based on the collective public key and a third public key;
- means for joining the first member node to a second entity that includes the first entity and the third member node and that uses secure communication with messages that are encrypted using the final shared secret key.

89. (Previously Presented) An apparatus as recited in Claim 88, further comprising means for creating and storing a subsequent shared secret key for use by the first entity and the third member node to enable the third member node to independently compute the group shared secret key, wherein the means for creating and storing the subsequent shared secret key further comprises means for creating and storing a subsequent shared secret key value, k, according to the relation:

$$k = p^{(a*x)(b*y)(c*z)} \bmod (q)$$

where:

p = a random number,

q = a prime number,

a = the first private key,

b = the second private key,

c = a third private key of the third member node,

x = a number of times the first member node has participated in entity
formation,

y = a number of times the second member node has participated in entity
formation, and

z = a number of times the third member node has participated in entity
formation.

90. (Previously Presented) An apparatus as recited in Claim 88, wherein the means for creating and storing the initial shared secret key for the first member node and second member node further comprises means for creating and storing an initial shared public key value "AB" according to the relation:

$$AB = k_{ab}^{ab} \bmod (q) = p^{(ab)(ab)} \bmod (q)$$

wherein:

k = the initial shared secret key,

a = the first private key,

b = the second private key,

p is a base value, and

q is a randomly generated prime number.

91. (Previously Presented) An apparatus as recited in Claim 81, further comprising:
means for authenticating a first multicast proxy service node with a subset of the
multicast proxy service nodes of the plurality of multicast proxy service nodes
that are affected by an addition of the first multicast proxy service node to the
multicast group, based on key information stored in a directory;

6 wherein the means for authenticating the first multicast proxy service node based on
7 key information stored in the directory includes means for authenticating the
8 first multicast proxy service node based on the directory that comprises a
9 directory system agent (DSA) for communicating with one or more of the
10 multicast proxy service nodes and a replication service agent (RSA) for
11 replicating attribute information of one or more multicast proxy service nodes,
12 wherein the attribute information comprises the group session key and the
13 private keys of the one or more multicast proxy service nodes;
14 means for receiving a plurality of private keys from the subset of multicast proxy
15 service nodes;
16 means for generating a new private key for the first multicast proxy service node;
17 means for communicating the plurality of private keys and the new private key to the
18 first multicast proxy service node;
19 means for communicating a message to the subset of multicast proxy service nodes
20 that causes the subset of multicast proxy service nodes to update their private
21 keys;
22 means for distributing the new group session key to all multicast proxy service nodes
23 of the plurality of multicast proxy service nodes by:
24 creating and storing the new group session key using a particular multicast
25 proxy service node of a particular domain of the plurality of domains
26 of the directory service, wherein the particular domain is associated
27 with the directory;
28 replicating the directory; and
29 obtaining the new group session key from a local multicast proxy service node
30 that is a replica of the first multicast proxy service node.

- 1 92. (Previously Presented) An apparatus as recited in Claim 91, further comprising
2 means for selectively updating the group session key and the private keys, wherein
3 the means for selectively updating further comprises:
4 means for detecting whether a member node of the plurality of member nodes that is
5 associated with one of the leaf nodes is leaving the multicast group;

6 means for determining one or more tree nodes along a tree path in the second binary
7 tree that corresponds to the leaving leaf node, wherein the one or more tree
8 nodes are affected in response to detecting whether the member node is
9 leaving;
10 means for updating the private keys of the one or more tree nodes;
11 means for one of the affected intermediate nodes that is a parent node of the leaving
12 leaf node generating the new group session key and selectively sending the
13 new group session key to all ancestral nodes along the tree path;
14 means for modifying the key information based upon the updated private keys and the
15 new group session key; and
16 means for generating instructions that distribute the modified key information using
17 directory replication.

- 1 93. (Previously Presented) An apparatus as recited in Claim 91, further comprising
2 means for selectively updating the group session key and the private keys, wherein
3 the means for selectively updating comprises:
4 means for receiving a request message from a new member node to join the multicast
5 group;
6 means for determining one or more tree nodes along a tree path in the second binary
7 tree that corresponds to a new leaf node in the second binary tree for the new
8 member node, wherein the one or more nodes are affected in response to
9 receiving the request message;
10 means for updating the private keys of the one or more tree nodes;
11 means for one of the affected intermediate nodes that is a parent node of the new leaf
12 node requesting permission from a root node of the second binary tree to
13 generate the new session key and generating the new group session key and a
14 private key of the new leaf node;
15 means for modifying the key information based upon the updated private keys, the
16 new group session key, and the private key of the new leaf node; and
17 means for generating instructions that distribute the modified key information using
18 directory replication.

1 94. (Previously Presented) An apparatus as recited in Claim 81, further comprising:
2 means for storing the group session key associated with the multicast group in a
3 directory of the directory service;
4 means for authenticating a first multicast proxy service node with a subset of
5 multicast proxy service nodes of the plurality of multicast proxy service nodes
6 that are affected by an addition of the first multicast proxy service node to the
7 multicast group, based on the group session key stored in the directory;
8 means for receiving a plurality of private keys from the subset of multicast proxy
9 service nodes;
10 means for receiving the new group session key for the multicast group, for use after
11 addition of the first multicast proxy service node, from a directory system
12 agent (DSA) of a local multicast proxy service node that has received the new
13 group session key through periodic replication of the directory by a replication
14 service agent (RSA) of the local multicast proxy service node, wherein the
15 RSA is signaled to carry out replication by storing an updated group session
16 key in a local node of the directory;
17 means for communicating the new group session key to the first multicast proxy
18 service node;
19 means for communicating a message to the subset of multicast proxy service nodes
20 that causes the subset of multicast proxy service nodes to update their private
21 keys.

1 95. (Previously Presented) An apparatus as recited in Claim 94, further comprising:
2 means for distributing the group session key to all member nodes of the plurality of
3 member nodes by creating and storing the group session key using a particular
4 multicast proxy service node of the plurality of multicast proxy service nodes,
5 wherein the particular multicast proxy service node is associated with a
6 particular domain of the plurality of domains, and wherein the particular
7 domain is associated with the directory;
8 means for replicating the directory; and

9 means for obtaining the group session key from a local multicast proxy service node
10 that is a replica of the particular multicast proxy service node.

1 96. (Previously Presented) An apparatus as recited in Claim 94, further comprising:
2 means for associating a plurality of intermediate nodes of the second binary tree with
3 a plurality of multicast service agents;
4 means for establishing a secure back channel group among the plurality of multicast
5 service agents;
6 means for updating the group session key to all the multicast service agents in the
7 plurality of multicast service agents by securely communicating the group
8 session key using a secure back channel that is associated with the secure back
9 channel group;
10 means for updating, at each intermediate node of the plurality of intermediate nodes,
11 the group session key of only those leaf nodes that are child nodes of said
12 each intermediate node.

1 97. (Previously Presented) An apparatus as recited in Claim 94, further comprising:
2 means for receiving a request for the group session key from a publisher node that is
3 located in a different domain of the plurality of domains from the particular
4 domain in which is stored the second binary tree;
5 means for determining an identifier of the publisher node using a first directory
6 service agent that is associated with a particular multicast proxy service node
7 of the plurality of multicast proxy service nodes, wherein the particular
8 multicast proxy service node is in the particular domain;
9 means for establishing a secure communication channel among the particular
10 multicast proxy service node and a directory service agent that is associated
11 with a different multicast proxy service node of the plurality of multicast
12 proxy service nodes, wherein the different multicast proxy service node is in
13 the different domain.

1 98. (Previously Presented) An apparatus as recited in Claim 81, further comprising
2 means for managing removal of a first member node from the multicast group,
3 wherein the means for managing further comprise:
4 means for creating and storing the group session key associated with the multicast
5 group and a private key associated with each member node of the plurality of
6 member nodes in a directory;
7 means for receiving information indicating that the first member node is leaving the
8 multicast group;
9 means for updating all affected keys of a subset of member nodes of the plurality of
10 member nodes in a branch of the second binary tree that contains the first
11 member node that is leaving;
12 means for receiving the new group session key for the multicast group, for use after
13 removal of the first member node, and a new private key for a parent node of
14 the first member node, from a local multicast proxy service node of the
15 plurality of multicast proxy service nodes;
16 means for communicating a message to the subset of member nodes that causes the
17 subset of member nodes to update their private keys.

1 99. (Previously Presented) An apparatus as recited in Claim 98, further comprising:
2 means for associating a plurality of intermediate nodes of the second binary tree with
3 a plurality of multicast service agents;
4 means for establishing a secure back channel group among the plurality of multicast
5 service agents;
6 means for updating the group session key to all the multicast service agents in the
7 plurality of multicast service agents by securely communicating the group
8 session key using a secure back channel that is associated with the secure back
9 channel group;
10 means for updating, at each intermediate node of the plurality of intermediate nodes,
11 the group session key of only those leaf nodes that are child nodes of said
12 each intermediate node.

1 100. (Previously Presented) An apparatus as recited in Claim 98, further comprising:
2 means for receiving a request for the group session key from a publisher node that is
3 located in a different domain of the plurality of domains from the particular
4 domain in which is stored the second binary tree;
5 means for determining an identifier of the publisher node using a first directory
6 service agent that is associated with a particular multicast proxy service node
7 of the plurality of multicast proxy service nodes, wherein the particular
8 multicast proxy service node is in the particular domain;
9 means for establishing a secure communication channel among the particular
10 multicast proxy service node and a directory service agent that is associated
11 with a different multicast proxy service node of the plurality of multicast
12 proxy service nodes, wherein the different multicast proxy service node is in
13 the different domain.

1 101. (Previously Presented) An apparatus as recited in Claim 98, further comprising:
2 means for distributing the group session key to all member nodes of the plurality of
3 member nodes by creating and storing the group session key using a particular
4 multicast proxy service node of the plurality of multicast proxy service nodes,
5 wherein the particular multicast proxy service node is associated with a
6 particular domain of the plurality of domains, and wherein the particular
7 domain is associated with the directory;
8 means for replicating the directory; and
9 means for obtaining the group session key from a local multicast proxy service node
10 that is a replica of the particular multicast proxy service node.

1 102. (New) A communication system for establishing a secure communication session
2 among a plurality of member nodes that participate in a multicast group across a wide
3 area network, the communication system comprising:
4 a plurality of multicast proxy service nodes that are distributed across the wide area
5 network and that are operable to control when any of the plurality of member
6 nodes join or leave the multicast group;

7 wherein each of the member nodes of the plurality of member nodes is operable to
8 establish multicast communication and to serve as a key distribution center;
9 first logic encoded in one or more tangible media for execution and when executed
10 operable to create and store a first binary tree that represents the plurality of
11 multicast proxy service nodes, wherein:
12 each node of the first binary tree is associated with a domain of a plurality of
13 domains of a directory service that is distributed across the wide area
14 network; and
15 each node of the first binary tree is associated with one or more multicast
16 proxy service nodes of the plurality of multicast proxy service nodes;
17 second logic encoded in one or more tangible media for execution and when executed
18 operable to:
19 create and store, in a particular domain of the plurality of domains of the
20 directory service that is distributed across the wide area network, a
21 second binary tree that represents the plurality of member nodes,
22 wherein:
23 each of the member nodes of the plurality of member nodes is
24 represented by a leaf node of the second binary tree; and
25 a root node of the second binary tree represents one or more of the
26 multicast proxy service nodes of the plurality of multicast
27 proxy service nodes;
28 create and store a group session key associated with the multicast group and a
29 private key associated with each member node of the multicast group
30 using secure key exchange; and
31 determine a new group session key by replicating a branch of the second
32 binary tree when an additional member node joins the multicast group.

1 103. (New) A communication system as recited in Claim 102, wherein each of the
2 member nodes is associated with at least one of the multicast proxy service nodes,
3 wherein each of the multicast proxy service nodes acts as one of a plurality of group
4 controllers, and wherein the second logic comprises logic which when executed is
5 operable to:

6 join an additional group controller to the plurality of group controllers, wherein each
7 group controller of the plurality of group controllers is a replica of another
8 group controller of the plurality of group controllers;
9 establish, by one of the group controllers, a secure communication channel between
10 one of the group controllers and another of the group controllers using a key
11 exchange protocol;
12 receive a request to add or delete a specified member node of the multicast group
13 from a load balancer that is coupled to the plurality of group controllers;
14 create and store the new group session key for each member node in each branch of
15 the second binary tree that is affected by adding or deleting the specified
16 member node from the multicast group;
17 distribute the new group session key from one of the group controllers to the member
18 nodes that are affected by adding or deleting the specified member node.

1 104. (New) A communication system as recited in Claim 103, wherein the logic operable
2 to distribute the new group session key further comprises logic which when executed
3 is operable to:
4 determine that the specified member node is leaving the multicast group;
5 determine which of the intermediate nodes of the second binary tree are affected by
6 the specified member node that is leaving;
7 update only keys associated with the intermediate nodes that are affected by the
8 specified member node that is leaving; and
9 send the new group session key to the leaf nodes of the second binary tree that
10 correspond to the member nodes that are affected by deleting the specified
11 member node.

1 105. (New) A communication system as recited in Claim 103, wherein the logic operable
2 to distribute the new group session key further comprises logic which when executed
3 is operable to:
4 receive a request message from the specified member node to join the multicast
5 group;

6 determine which of the intermediate nodes of the second binary tree are affected by
7 the specified member node that is joining the multicast group;
8 update only keys associated with the intermediate nodes that are affected by the
9 specified member node that is joining;
10 generate a private key for the specified member node that is joining; and
11 send a message comprising the new group session key, the private key, and the
12 updated keys of intermediate nodes that are affected to the member node that
13 is joining.

1 106. (New) A communication system as recited in Claim 102, wherein the logic operable
2 to determine the new group session key further comprises logic which when executed
3 is operable to compute a group shared secret key at a first member node of the
4 plurality of member nodes for use in a public key process and to use less than $n * (n -$
5 $1)$ messages, wherein “n” is a number of member nodes in the multicast group,
6 wherein the logic operable to compute the group shared secret key comprises logic
7 which when executed is operable to:
8 generate an intermediate shared secret key by issuing communications to a second
9 member node of the plurality of member nodes;
10 send a first private value associated with the first member node to the second member
11 node;
12 receive from the second member node a second private value associated with the
13 second member node using the intermediate shared secret key;
14 generate and communicate a collective public key that is based upon the first private
15 value and the second private value to a third member node of the plurality of
16 member nodes;
17 receive an individual public key from the third member node; and
18 compute and store the group shared secret key based upon the individual public key.

1 107. (New) A communication system as recited in Claim 106, wherein the logic operable
2 to communicate the collective public key further comprises logic which when
3 executed is operable to determine whether the first member node or the second

4 member node transfers the collective public key based upon an order of entry of the
5 first and second member nodes into the multicast group.

1 108. (New) A communication system as recited in Claim 106, wherein the logic operable
2 to compute and store the group shared secret key further comprises logic which when
3 executed is operable to compute and store a group shared secret key value “k” at the
4 first member node according to the relation:

5
$$k = C^{ab} \bmod (q) = p^{abc} \bmod (q);$$

6 wherein:

7 C, a, b, c, q, and p are values stored in a memory,

8 C is the individual public key,

9 a is the first private value of the first member node,

10 b is the second private value of the second member node,

11 c is a third private value of the third member node,

12 p is a base value, and

13 q is a prime number value.

1 109. (New) A communication system as recited in Claim 102, wherein the logic operable
2 to determine the new group session key further comprises logic which when executed
3 is operable to compute a group shared secret key, each of the member nodes of the
4 plurality of member nodes having a private key associated therewith, wherein the
5 logic operable to compute the group shared secret key comprises logic which when
6 executed is operable to:

7 communicate a first public key of a first member node of the plurality of member
8 nodes to a second member node of the plurality of member nodes;

9 create and store an initial shared secret key for the first member node and the second
10 member node based on a first private key and a second public key that is
11 received from the second member node;

12 create and store information at the first member node that associates the first member
13 node with a first entity by generating a collective public key that is shared by
14 the first member node and the second member node, wherein the collective

15 public key is based on the first private key and a second private key that is
16 derived by the first member node from the second public key;
17 receive a third public key from a third member node of the plurality of member nodes
18 that seeks to join the first entity;
19 create and store a final shared secret key based on the collective public key and a
20 third public key;
21 join the first member node to a second entity that includes the first entity and the third
22 member node and that uses secure communication with messages that are
23 encrypted using the final shared secret key.

1 110. (New) A communication system as recited in Claim 109, wherein the second logic
2 comprises logic which when executed is operable to create and store a subsequent
3 shared secret key for use by the first entity and the third member node to enable the
4 third member node to independently compute the group shared secret key, wherein
5 the logic operable to create and store the subsequent shared secret key comprises
6 logic which when executed is operable to create and store a subsequent shared secret
7 key value, k , according to the relation:

$$k = p^{(a*x)(b*y)(c*z)} \bmod (q)$$

9 wherein:

10 p = a random number,

11 q = a prime number,

12 a = the first private key,

13 b = the second private key,

14 c = a third private key of the third member node,

15 x = a number of times the first member node has participated in entity
16 formation,

17 y = a number of times the second member node has participated in entity
18 formation, and

19 z = a number of times the third member node has participated in entity
20 formation.

1 111. (New) A communication system as recited in Claim 109, wherein the logic operable
2 to create and store the initial shared secret key for the first member node and second
3 member node further comprises logic which when executed is operable to create and
4 store an initial shared public key value "AB" according to the relation:

5
$$AB = k_{ab}^{ab} \bmod (q) = p^{(ab)(ab)} \bmod (q)$$

6 wherein:

7 k = the initial shared secret key,

8 a = the first private key,

9 b = the second private key,

10 p is a base value, and

11 q is a randomly generated prime number.

1 112. (New) A communication system as recited in Claim 102, wherein the second logic
2 comprises logic which when executed is operable to:

3 authenticate a first multicast proxy service node with a subset of the multicast proxy
4 service nodes of the plurality of multicast proxy service nodes that are
5 affected by an addition of the first multicast proxy service node to the
6 multicast group, based on key information stored in a directory;

7 wherein authenticating the first multicast proxy service node based on key
8 information stored in the directory includes authenticating the first multicast
9 proxy service node based on the directory that comprises a directory system
10 agent (DSA) for communicating with one or more of the multicast proxy
11 service nodes and a replication service agent (RSA) for replicating attribute
12 information of one or more multicast proxy service nodes, wherein the
13 attribute information comprises the group session key and the private keys of
14 the one or more multicast proxy service nodes;

15 receive a plurality of private keys from the subset of multicast proxy service nodes;

16 generate a new private key for the first multicast proxy service node;

17 communicate the plurality of private keys and the new private key to the first

18 multicast proxy service node;

19 communicate a message to the subset of multicast proxy service nodes that causes the
20 subset of multicast proxy service nodes to update their private keys;
21 distribute the new group session key to all multicast proxy service nodes of the
22 plurality of multicast proxy service nodes, wherein the logic operable to
23 distribute the new group session key to all multicast proxy service nodes
24 further comprises logic which when executed is operable to:
25 create and store the new group session key using a particular multicast proxy
26 service node of a particular domain of the plurality of domains of the
27 directory service, wherein the particular domain is associated with the
28 directory;
29 replicate the directory; and
30 obtain the new group session key from a local multicast proxy service node
31 that is a replica of the first multicast proxy service node.

1 113. (New) A communication system as recited in Claim 112, wherein the second logic
2 comprises logic which when executed is operable to selectively update the group
3 session key and the private keys, wherein the logic operable to selectively update the
4 group session key and the private keys further comprise logic which when executed is
5 operable to:
6 detect whether a member node of the plurality of member nodes that is associated
7 with one of the leaf nodes is leaving the multicast group;
8 determine one or more tree nodes along a tree path in the second binary tree that
9 corresponds to the leaving leaf node;
10 update the private keys of the one or more tree nodes;
11 at one of the affected intermediate nodes that is a parent node of the leaving leaf
12 node, generate the new group session key and selectively send the new group
13 session key to all ancestral nodes along the tree path;
14 modify the key information based upon the updated private keys and the new group
15 session key; and
16 generate instructions that distribute the modified key information using directory
17 replication.

1 114. (New) A communication system as recited in Claim 112, wherein the second logic
2 comprises logic which when executed is operable to selectively update the group
3 session key and the private keys, wherein the logic operable to selectively update the
4 group session key and the private keys further comprises logic which when executed
5 is operable to:
6 receive a request message from a new member node to join the multicast group;
7 determine one or more tree nodes along a tree path in the second binary tree that
8 corresponds to a new leaf node in the second binary tree for the new member
9 node;
10 update the private keys of the one or more tree nodes;
11 at one of the affected intermediate nodes that is a parent node of the new leaf node,
12 request permission from a root node of the second binary tree to generate the
13 new session key and to generate the new group session key and a private key
14 of the new leaf node;
15 modify the key information based upon the updated private keys, the new group
16 session key, and the private key of the new leaf node; and
17 generate instructions that distribute the modified key information using directory
18 replication.

1 115. (New) A communication system as recited in Claim 102, wherein the second logic
2 comprises logic which when executed is operable to:
3 store the group session key associated with the multicast group in a directory of the
4 directory service;
5 authenticate a first multicast proxy service node with a subset of multicast proxy
6 service nodes of the plurality of multicast proxy service nodes that are
7 affected by an addition of the first multicast proxy service node to the
8 multicast group, based on the group session key stored in the directory;
9 receive a plurality of private keys from the subset of multicast proxy service nodes;
10 receive the new group session key for the multicast group, for use after addition of the
11 first multicast proxy service node, from a directory system agent (DSA) of a
12 local multicast proxy service node that has received the new group session key
13 through periodic replication of the directory by a replication service agent

14 (RSA) of the local multicast proxy service node, wherein the RSA is signaled
15 to carry out replication by storing an updated group session key in a local
16 node of the directory;
17 communicate the new group session key to the first multicast proxy service node;
18 communicate a message to the subset of multicast proxy service nodes that causes the
19 subset of multicast proxy service nodes to update their private keys.

1 116. (New) A communication system as recited in Claim 115, wherein the second logic
2 comprises logic which when executed is operable to:
3 distribute the group session key to all member nodes of the plurality of member
4 nodes, wherein the logic operable to distribute the group session key to all
5 member nodes further comprises logic which when executed is operable to
6 create and store the group session key using a particular multicast proxy
7 service node of the plurality of multicast proxy service nodes, wherein the
8 particular multicast proxy service node is associated with a particular domain
9 of the plurality of domains, and wherein the particular domain is associated
10 with the directory;
11 replicate the directory; and
12 obtain the group session key from a local multicast proxy service node that is a
13 replica of the particular multicast proxy service node.

1 117. (New) A communication system as recited in Claim 115, wherein the second logic
2 comprises logic which when executed is operable to:
3 associate a plurality of intermediate nodes of the second binary tree with a plurality of
4 multicast service agents;
5 establish a secure back channel group among the plurality of multicast service agents;
6 update the group session key to all the multicast service agents in the plurality of
7 multicast service agents by securely communicating the group session key
8 using a secure back channel that is associated with the secure back channel
9 group;

10 at each intermediate node of the plurality of intermediate nodes, update the group
11 session key of only those leaf nodes that are child nodes of said each
12 intermediate node.

1 118. (New) A communication system as recited in Claim 115, wherein the second logic
2 comprises logic which when executed is operable to:
3 receive a request for the group session key from a publisher node that is located in a
4 different domain of the plurality of domains from the particular domain in
5 which the second binary tree is stored;
6 determine an identifier of the publisher node using a first directory service agent that
7 is associated with a particular multicast proxy service node of the plurality of
8 multicast proxy service nodes, wherein the particular multicast proxy service
9 node is in the particular domain;
10 establish a secure communication channel among the particular multicast proxy
11 service node and a directory service agent that is associated with a different
12 multicast proxy service node of the plurality of multicast proxy service nodes,
13 wherein the different multicast proxy service node is in the different domain.

1 119. (New) A communication system as recited in Claim 102, wherein the second logic
2 comprises logic which when executed is operable to manage removal of a first
3 member node from the multicast group, wherein the logic operable to manage
4 removal of the first member node further comprises logic which when executed is
5 operable to:
6 create and store the group session key associated with the multicast group and a
7 private key associated with each member node of the plurality of member
8 nodes in a directory;
9 receive information indicating that the first member node is leaving the multicast group;
10 update all affected keys of a subset of member nodes of the plurality of member
11 nodes in a branch of the second binary tree that contains the first member
12 node that is leaving;
13 receive the new group session key for the multicast group, for use after removal of the
14 first member node, and a new private key for a parent node of the first

15 member node, from a local multicast proxy service node of the plurality of
16 multicast proxy service nodes;
17 communicate a message to the subset of member nodes that causes the subset of
18 member nodes to update their private keys.

1 120. (New) A communication system as recited in Claim 119, wherein the second logic
2 comprises logic which when executed is operable to:
3 associate a plurality of intermediate nodes of the second binary tree with a plurality of
4 multicast service agents;
5 establish a secure back channel group among the plurality of multicast service agents;
6 update the group session key to all the multicast service agents in the plurality of
7 multicast service agents, wherein the logic operable to update the group
8 session key to all the multicast service agents further comprises logic which
9 when executed is operable to securely communicate the group session key
10 using a secure back channel that is associated with the secure back channel
11 group;
12 at each intermediate node of the plurality of intermediate nodes, update the group
13 session key of only those leaf nodes that are child nodes of said each
14 intermediate node.

1 121. (New) A communication system as recited in Claim 119, wherein the second logic
2 comprises logic which when executed is operable to:
3 receive a request for the group session key from a publisher node that is located in a
4 different domain of the plurality of domains from the particular domain in
5 which the second binary tree is stored;
6 determine an identifier of the publisher node using a first directory service agent that
7 is associated with a particular multicast proxy service node of the plurality of
8 multicast proxy service nodes, wherein the particular multicast proxy service
9 node is in the particular domain;
10 establish a secure communication channel among the particular multicast proxy
11 service node and a directory service agent that is associated with a different

12 multicast proxy service node of the plurality of multicast proxy service nodes,
13 wherein the different multicast proxy service node is in the different domain.

1 122. (New) A communication system as recited in Claim 119, wherein the second logic
2 comprises logic which when executed is operable to:
3 distribute the group session key to all member nodes of the plurality of member
4 nodes, wherein the logic operable to distribute the group session key to all
5 member nodes further comprises logic which when executed is operable to
6 create and store the group session key using a particular multicast proxy
7 service node of the plurality of multicast proxy service nodes, wherein the
8 particular multicast proxy service node is associated with a particular domain
9 of the plurality of domains, and wherein the particular domain is associated
10 with the directory;
11 replicate the directory; and
12 obtain the group session key from a local multicast proxy service node that is a
13 replica of the particular multicast proxy service node.